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TRICHILOGASTER ACACIAE-LONGIFOLIAE (FROGGATT) (HYMENOPT., CHALCIDOIDEA), A WASP CAUSING GALLING OF THE FLOWER-BUDS OF *ACACIA LONGIFOLIA* WILLD., *A. FLORIBUNDA* SIEBER AND *A. SOPHORAE* R. BR.

By N. S. Noble, D.Sc.Agr., M.Sc., D.I.C.

(*Entomologist, Department of Agriculture, New South Wales.*)

Communicated by Dr. A. D. Imms, F.R.S.

With Plates 1 to 2 and Eight Figs. in the Text.

(Manuscript received 5.ix.1939.)

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Introduction.[1]

Since 1932 I have had under observations galls on *Acacia longifolia*, *A. floribunda* and *A. sophorae* growing in various parts of the Sydney district. Photos of these mature galls are shown in Plates 2A, 2B and 2C, and it will be seen that though the galls from the different species of *Acacia* differ somewhat

[1] This is one of ten papers on Australian Chalcidoidea submitted, in August 1937, to the University of Sydney in fulfilment of the requirements for the degree of Doctor of Science in Agriculture. After submitting the thesis, observations continued to be made on this species until the commencement of emergence of the adults from the galls in November 1938, and these additional data are included in the present paper.

in size and shape, all are large, rounded, green and fleshy. The mature galls vary from half an inch up to one and a half inches in diameter. Those occurring on *A. floribunda* are mainly smooth and spherical and dark green. The galls on *A. longifolia* are generally larger than those occurring on *A. floribunda*, those on *A. sophorae* being particularly massive, green, irregular in shape, and with somewhat roughened surfaces. *Acacia longifolia*, the "Sydney Golden Wattle," a shrub or small tree, which is commonly cultivated as an ornamental, is typically a coastal species, but it also occurs on the Tablelands of New South Wales. The phyllodes vary from 2 to 6 inches in length, this species being rather variable in character (Anderson, 1934). *Acacia floribunda*, one of several species of wattle known as "Sally," is allied to *A. longifolia*, but has narrower phyllodes, and is usually more bushy and often rather larger, occasionally reaching 40 feet in height. It is a common coastal species, frequently found along creeks and river banks (Anderson, 1934). *A. sophorae*, once considered a variety of *A. longifolia*, is not as common as the other two species.

All three species under discussion flower mainly during August and September each year, but the flowering period is influenced by seasonal conditions and may vary somewhat from year to year. Flowering at times may commence in July, and trees have been observed in flower in October.

Although *A. floribunda* and *A. longifolia* grow extensively in the Sydney district, on comparatively few trees are galls to be found, but on trees in which galls are present, they usually occur in large numbers. As will be pointed out later, this is connected with the poor powers of flight of the adult gall wasps, which generally oviposit in trees bearing the galls from which they have emerged, leaving adjacent acacias of the same species unattacked. In November 1932, numbers of these galls were collected and 8 species of Chalcidoids, one species of Braconid and an Ichneumonid were bred out, the predominant species being *Trichilogaster acaciae-longifoliae* (Froggatt). It was not possible to make detailed observations on the development of these galls until 1936, but in the spring of that year, large numbers of galls were collected and the adult wasps of the various species were again bred out. A number of potted *A. sophorae* trees which were two years old and from three to four feet in height were enclosed in cellophane sleeves, and adults of the more commonly occurring species of wasps were introduced.

It was found that females of *Trichilogaster acaciae-longifoliae* were the only ones which would oviposit in the young flower-buds of these acacias. Some months later the typical galls developed on these trees and from these, adults of *T. acaciae-longifoliae* emerged in November 1937, thus proving that this species was the primary gall former and that its life-cycle was annual. The adults of *T. acaciae-longifoliae* were again enclosed with these same trees in November 1937, and in the following year a further batch of galls was developed. In addition, in 1936, it was found that adults of *T. acaciae-longifoliae* emerging from galls on *A. longifolia* readily oviposited in uninfested twigs on *Acacia floribunda*, and the adult wasps used to produce the experimental galls on *A. sophorae* were obtained from galls on *A. floribunda*.

In December 1937 females of *T. acaciae-longifoliae* which emerged from galls on *Acacia floribunda* were enclosed with young seedlings of *Acacia longifolia*, which at the time were eighteen months old. These seedlings subsequently grew rapidly and flowered for the first time in July and August, 1938, at which time the typical, but only partly grown, galls were present. In the following spring these galls matured and later adults of *T. acaciae-*

longifoliae emerged. It is evident therefore that this species is responsible for the formation of the galls on all three species of *Acacia* mentioned.

The galls under discussion were first noted by Froggatt (1892) on *Acacia longifolia* at Rose Bay and Botany, suburbs of Sydney. He bred out the adult wasps which he described as *Cynips acaciae-longifoliae*, being under the impression that it was a species of Cynipid. Subsequently Froggatt (1925) referred to galls on *A. floribunda* at Croydon, Sydney, caused by *T. acaciae-longifoliae* and stated that every flower-bud on the tree had been aborted into a gall. Up to the time of my investigations no experimental evidence had been brought forward to show that out of the various species of insects occurring in these galls that of *T. acaciae-longifoliae* was the primary gall former. Froggatt (1892) also described *Trichilogaster* (*Cynips*) *acaciae-discoloris* from galls on *Acacia discolor* and *T.* (*Cynips*) *maideni* from galls on *Acacia longifolia* both in the Sydney district. Subsequently Mayr (1905) transferred Froggatt's three species of *Cynips* to the genus *Trichilogaster* which he established at that time, and placed this genus in the family PERILAMPIDAE. Mayr (1905) also described *Trichilogaster pendulae* from galls on *Acacia pendula* in New South Wales.

Girault (1913) described a new genus *Epiperilampus* and a new species *E. xanthocephalus* in the family PERILAMPIDAE. Subsequently Girault (1913A) described a further three new species in the genus *Epiperilampus* and he expressed the opinion that this genus was closely allied to the genus *Trichilogaster* Mayr, and that it was probably a synonym of it. Two years later Girault (1915) described a further new species, *Epiperilampus ater* from acacia galls in Queensland. In the following year Girault (1916) stated that *Epiperilampus* was a synonym of *Trichilogaster* Mayr.

There have thus been published descriptions of eight species in the genus *Trichilogaster* from Australia. The habits of several species are so far unknown, but the remainder have been bred from galls on various acacias.

In a recent letter to me Girault stated that his *Epiperilampus xanthocephalus* was a synonym of *Trichilogaster acaciae-longifoliae* (Froggatt), the species under discussion here.

Girault (1913A), when discussing the genera *Trichilogaster*, *Epiperilampus* and the allied *Perilampoides*, stated that: " These gall-making genera seem true Perilampids in spite of the long scutellum in some of them, and in the longer depressed abdomen. They have the habitus, in some cases, of the Encyrtid tribe Taneostigmini, but there are no Encyrtid characters. They are allied with CLEONYMIDAE and EURYTOMIDAE."

Subsequently Gahan (1922), referring to species of *Trichilogaster* and a few other species of phytophagous Perilampids, stated: " The writer is strongly inclined to doubt the relationship of these gall making forms to true Perilampids. They appear to be more closely related to the Decatomini and it is not improbable that all these so-called Perilampids really belong to the EURYTOMIDAE (?) and that they should constitute a separate subfamily made up of many genera now placed in the PERILAMPIDAE as well as several from the Pteromalid tribe Isoplatini. The writer is not willing to commit himself definitely on this point without further study."

It is evident that the correct systematic position of this gall wasp genus is still a matter of some doubt. The great majority of the members of the family PERILAMPIDAE are true parasites, and if the members of the genus *Trichilogaster* are correctly placed, then they form part of a small isolated group

which exhibits a behaviour very far removed from that of the majority of the members of this family.

In subsequent pages is set out the detailed life-history of *T. acaciae-longifoliae*, together with observations on the development of the galls. Notes on some of the other species of insects occurring in the galls are also included.

The study of the egg and larval stages of gall-inhabiting species present the same difficulties as do those of internal parasites, in that observations can only be made as a result of dissection, this operation invariably resulting in the death of the occupant. The complete life-history can only be built up as a result of many hundreds of dissections, carried out at frequent intervals over a period of at least twelve months. This was done in the study of *T. acaciae-longifoliae*, galls being collected from trees from the various infested acacias in the different suburbs of Sydney and from acacias growing in the Botanic Gardens, Sydney. Observations were also made on the acacias on which galls were produced experimentally at my home at Lindfield, Sydney.

The study of the immature stages of *T. acaciae-longifoliae* is also complicated by the fact that there is no external evidence of gall formation or abnormality of the flower-buds for many months after oviposition has taken place.

Morphology.

The adult.

Description of female :—

The following is Froggatt's (1892) original description of *Trichilogaster acaciae-longifoliae* :—

" Length of body, 2 lines. Expanse of wings 4¼ lines.

Head, thorax, antennae, and centre of upperside of abdomen from below second segment to tip of abdomen ochreous-yellow; eyes and ocelli dark brown; first two segments of abdomen and the edges of the following ones black, the colour fading in old specimens to an ochreous-brown; underside of abdomen black. Antennae inserted below the eyes in a depression; 13 jointed; 1st slender, cylindrical; 3rd–4th small, funnel shaped; 5th–10th rounded at base and square at apex; 11th–13th forming a club; all from the second joint margined with fine hairs. Head rounded in front and not hollowed behind; eyes and ocelli dark brown. Prothorax narrow; middle lobe of mesonotum large, rounded in front, lateral lobes wedge-shaped; scutellum large, rounded in front, heart-shaped. Abdomen broad and rounded at base, with a depression in the centre, rather pointed at apex. Wings large, hyaline; costa and nervures black; fore-wings clouded with a fuscous patch about ⅔rd from the tip of wing. Legs clothed with fine hairs.

Locality : Rose Bay, Botany, etc."

Of *T. acaciae-longifoliae* Girault (1916), who examined specimens forwarded by Froggatt to the U.S. National Museum, stated :—

" In *Trichilogaster acaciae-longifoliae* Froggatt the base of the abdomen is orange except narrowly at meson; the antennae are not inserted below the eyes, but in the middle of the face; the brown cloud on the fore-wing is from the apex of the submarginal vein and the rest of the wing is sub-hyaline. Venation reddish-brown."

Notes on the female :—

The average length of the female (fig. 1) is 3·78 mm., the maximum being 4·01 mm. and the minimum 3·39 mm. Froggatt's description is not satis-

factory. I have compared specimens from *A. longifolia* and *A. floribunda* with specimens labelled "*T.a-longifoliae*" by Froggatt in the collection of the N.S.W. Department of Agriculture. These wasps were collected on 9th November, 1891, at Rose Bay, which is the time and locality at which the type material was collected and the two batches of wasps agree, so that there is little doubt that the species under discussion is Froggatt's *Trichilogaster acaciae-longifoliae.* The wasp is very robust and broad in proportion to its length, and having the head, thorax and part of the abdomen ochreous, it differs markedly from any other species in this genus seen by me.

A large number of specimens was examined, and in all, the colours were very constant. The eyes are red and not brown as stated by Froggatt. The antennae are inserted between the eyes and not below, and the base of the

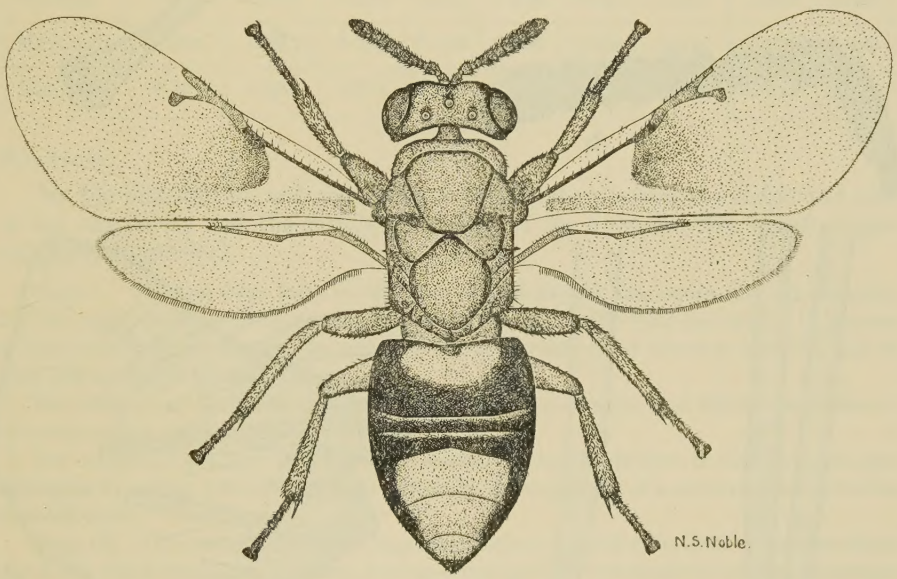

Fig. 1.—*T. acaciae-longifoliae* (Froggatt); Adult female (× 50).

dorsal surface of the abdomen is not black, there being a variable portion of the base of the first segment ochreous. The remainder of the first segment and the dorsal surface of the second and third segments are black and the remainder of the dorsal surface is ochreous and the lateral and ventral surface of the abdomen is black. The coxae, trochanters and a variable portion of the basal portion of the femora are dark brown to black, the remainder of the legs being ochreous, the tips of the last tarsal segments being darker. The setae on the wings are extremely short and poorly developed. The hind-wings are fringed with fairly long setae, but the front wings are unfringed except the distal portion of the basal margins, and the lower half of the distal margins which bear a limited number of short setae.

The antenna (fig. 2, B), the stigmal knob (fig. 2, E), the mandible (fig. 2, F), the ventral view of the tip of the ovipositor sheath (fig. 2, C), and the lateral view of the tip of the stylet (fig. 2, D) are illustrated.

Notes on the male :—

The average length of the male is 2·92 mm., the maximum being 3·07 mm. and the minimum 2·71 mm. The male is remarkably similar to the males of other species of *Trichilogaster* seen by me. It is a slender insect, being both shorter and much less robust than the female. The eyes are red, the head and thorax being black, the abdomen being uniformly dark brown to black. Superficially the male might be mistaken for another species (fig. 2, A).

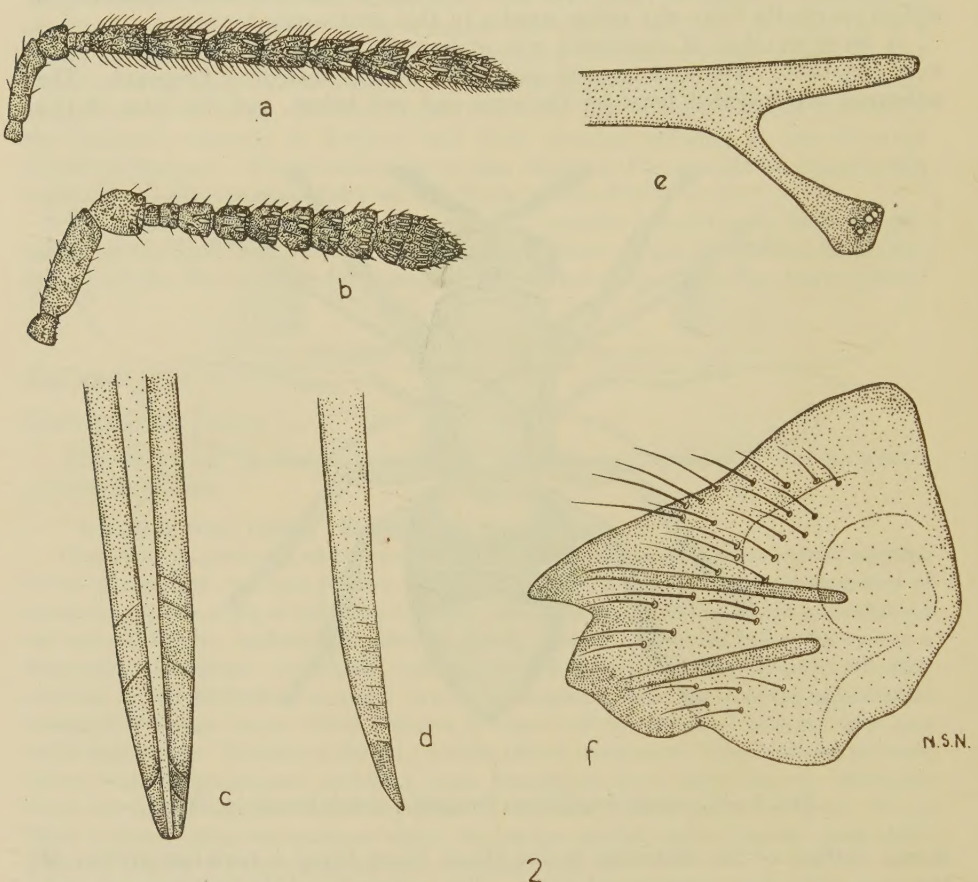

Fig. 2.—*T. acaciae-longifoliae* (Froggatt); A, antenna of male (× 120); B, antenna of female (× 120); C, ventral view of tip of ovipositor stylet (× 600); D, lateral view of C; E, stigmal knob of female (× 184); F, mandible of female (× 345).

The egg.

The egg resembles that of *Tepperella trilineata*, an allied species causing galls on the flower-buds of *Acacia decurrens* (Noble, 1938A). The ovarian egg consists of two white oval bodies joined by a narrow connecting tube, which is at first folded (fig. 3, A) and which prior to oviposition becomes extended (fig. 3, B). After deposition, as is customary, all the protoplasm passes into one end, forming a large oval body and leaving a large flaccid pedicel (fig. 3, C).

The dimensions of the egg are set out in table I.

TABLE I.

Dimensions of egg of *T. acaciae-longifoliae* (in millimetres).

	Eggs dissected from ovaries						Width of connecting tube	Eggs immediately after deposited	
	Length with connecting tube folded	Length with connecting tube extended	Larger body		Smaller body			Body	
			Length	Width	Length	Width		Length	Width
Average	0·472	0·604	0·224	0·058	0·186	0·053	0·005	0·227	0·080
Maximum	0·528	0·0637	0·238	0·066	0·205	0·056	0·006	0·238	0·089
Minimum	0·423	0·561	0·211	0·053	0·172	0·050	0·004	0·215	0·073

The larva.

By the distribution and size of the integumentary setae, the shape and size of the mandibles and the number and size of the spiracles five larval stages can be distinguished.

Stage I. The first stage larva is only very slightly arched and tapers only very slightly to both ends, the thoracic segments being conspicuously wider than the head. It is more or less translucent except for the region of the alimentary tract which is greenish, and is only just visible to the unaided eye.

The integument is smooth and glistening and devoid of setae, and there is no evidence of a respiratory system.

The mandibles are very pale amber in colour, average 0·009 mm. in diameter, and are triangular in outline with one pointed tooth, with the suggestion of a much shorter and more rounded tooth.

Stage II. The second stage larva in general outline resembles the first. The mandibles (fig. 3, E), which are amber in colour, average 0·015 mm., are triangular in outline, bidentate with one long curved tooth. Beneath the mandibles, there are five minute sensillae and laterally two short setae; no setae are present on the abdominal segments. A limited tracheal system is now present. One pair of spiracles on the second segment can be seen developing on the maturing larva of the first stage and these are open in the second stage, there being present two lateral tracheal trunks, and a limited number of branches.

Stage III. The third stage larva (fig. 3, D) in general outlines still resembles those of the first and second stage, being only slightly arched, and tapering only slightly. To the unaided eye the larva appears to be greenish-white, but under the microscope it is somewhat translucent, the alimentary tract, which is dorsal, being greenish or golden.

The mandibles (fig. 3, F) are amber, unevenly bidentate as in the preceding stage and average 0·026 mm. in length. The distribution of setae and sensillae beneath the mandibles is exactly the same as in the preceding stage, and the respiratory system is still very similar, there being one pair of open spiracles on the second segment.

Stage IV. In general outline the fourth stage larva resembles much more closely the larva of the fifth stage. It is cylindrical and arched, and tapering to both ends, and is greenish-white in colour, and consists of a head and thirteen segments.

The mandibles (fig. 3, G) average 0·045 mm. in length, the maximum being 0·053 mm. and the minimum 0·040 mm. They are light brown in colour and in general shape like

those of the preceding stage, but are more heavily sclerotised and occasionally a division is present in the shorter tooth.

On the underside of the head and dorsally and laterally on the first segment, and in very limited numbers on the dorsal surface of the second and third segment, are minute papillae visible only at high magnifications. The distribution of setae and sensillae on the head is similar to that of the fifth stage larva.

The abdominal segments carry setae of variable length and number in different individuals, their length varying on the same segment. These are quite prominent on the first segment and form a complete circlet. On the second segment the setae are much smaller, more limited in number and confined to the dorsal and lateral surface. On the

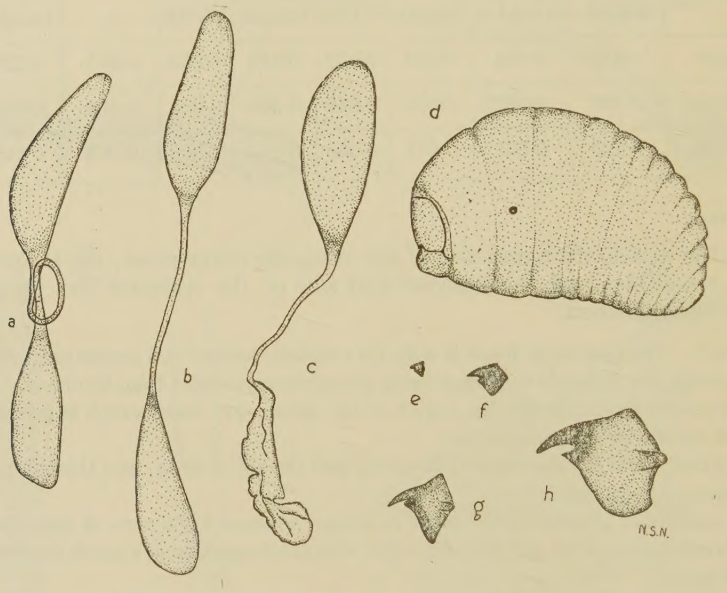

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Fig. 3.—*T. acaciae-longifoliae* (Froggatt); A, ovarian egg with connecting tube folded; B, ovarian egg with connecting tube extended; C, egg after a few hours of deposition (all × 250); D, lateral view of third stage larva (× 135); E, mandible of second stage larva; F, mandible of third stage larva; G, mandible of fourth stage larva; H, mandible of fifth stage larva (all × 440).

succeeding segments the distribution of these setae is variable. There is at least one pair of lateral setae on each segment and in some of the posterior segments the number varies from two to four, while on the last segment up to 8 setae are present and are directed posteriorly.

On the median segments these setae are only just visible at very high magnifications, but are slightly larger on the posterior segments.

The respiratory system is very well developed, there being nine pairs of spiracles, one pair on each segment from the second to the tenth inclusive. The first pair of spiracles is much the largest, and the third pair much the smallest. Internally profusely branching tracheae pass to the various organs.

Stage V. The fifth or last stage larva is cylindrical and arched, white in colour, and tapers to both ends, and consists of a head and thirteen segments.

The average length of the mature larva is 4·93 mm., the maximum being 5·47 mm. and the minimum being 4·48 mm. The average width is 1·37 mm., the maximum being 1·59 mm., and the minimum 1·15 mm.

The mandibles (fig. 3, H) are dark brown in colour and are bidentate, there being one large curved tooth and one very short tooth. The latter is occasionally minutely divided to two short sharp teeth. The mandibles, however, are always more or less triangular in outline. Their average length is 0·093 mm., the maximum being 0·102 mm. and the minimum 0·083 mm.

Just above the mandibles there is a pair of setae; another somewhat larger pair of setae being to the sides of the mandibles.

Just beneath the mandibles there is a further pair of minute setae and below these and a little wider apart there is a pair of truncate cone-shaped structures between which there are three sensillae, while below these again there is a larger fourth pair of setae, which are the largest on the head.

All over the first and second segments and dorsally and laterally on succeeding segments there are numbers of short pointed papillae. These become smaller and less numerous

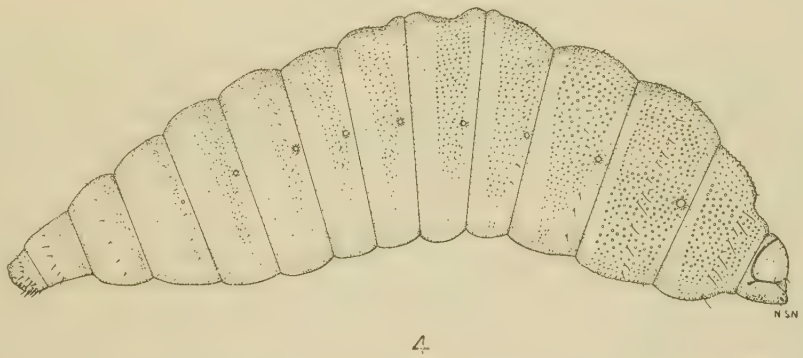

FIG. 4.—*T. acaciae-longifoliae* (Froggatt); lateral view of mature larva (× 40).

and more confined to the dorsal surface on the intermediate segments, but on the posterior segments, with the exception of the last, they become somewhat larger and again extend down to the ventral surface. In some larvae at high magnifications a limited number of these papillae can be distinguished on the underside of the head. All segments bear numbers of prominent sharp pointed amber setae arising from papillae, their size and number differing in different individuals, while there may be considerable variation in the size of the setae on the same segment, some setae being as much as three times as long as others on the same segment. From 15 to 22 setae have been counted on the first segment. These encircle the larva, and are longer than those on any of the other segments. The average length of the longest seta on the first segment of ten larvae was 0·101 mm., the maximum being 0·114 mm. and the minimum 0·091 mm. On segments two and three the setae also form a circlet, but while shorter than those on the first segment, they are always more numerous, up to 29 on the second and 27 on the third having been counted. On segments four to eleven inclusive, the number of setae is smaller and more regular and they are confined more to a single row on the dorsal and upper-lateral surface. On the posterior segments the setae become somewhat larger and on the twelfth again form a single row round the larva. On the last segment there is a marked increase in the number of setae present, up to 29 having been counted, and these are scattered over its surface. They consist of a number of dark amber setae, not quite as long as those on the first

segment, but more robust. These are directed posteriorly, while dorsally there are a number of much shorter setae directed more at right angles to the surface.

Nine pairs of spiracles are present, one pair being on each segment from two to ten inclusive, those on the second segment being the largest. They are amber in colour and project somewhat from the surface of the integument. A profusely branching tracheal system is present.

The preceding description applies to the female larva. The fifth stage male larva, while similar in general respects, is less robust and shorter. The distribution of setae is much the same as in the female larva, but the setae on the male larva are shorter and less numerous. The mandible of the male larva is of the same general shape but is slightly smaller, and none was ever observed in which the shorter rounded tooth was bifid. The average length of the mandible of the mature male larva is 0·082 mm., the maximum being 0·088 mm. and the minimum 0·078 mm.

Biology.

Habits of adults.

Like other gall wasps which I have studied, the adults are rather sluggish and somewhat degenerate in appearance. They crawl rather than fly and not uncommonly fall over and find difficulty in regaining their normal upright position. Though provided with sugar and water solution none was ever observed to feed. In the field adults have been observed in flight but they are not vigorous fliers.

As with other gall wasps, females tend to oviposit in the trees bearing the galls from which they emerged, and when liberated beneath one particular tree, will neglect others of the same variety growing near at hand. At my home an *Acacia longifolia*, growing only 24 feet away from an *A. sophorae*, remained uninfested throughout the period of these studies, though large numbers of females emerged from and reinfested *A. sophorae*. At the same time *A. longifolia* trees of exactly the same age and growing in another part of my home became heavily galled following upon the liberation of numbers of adults of *T. acaciae-longifoliae* amongst their foliage. These *A. longifolia* trees which became galled were only 49 feet away from those of the same age and species which remained ungalled.

Length of life of adults.

As females far outnumber males, the number of the latter available for longevity experiments was limited. Under laboratory conditions, and when held in 6 × 1″ tubes and provided with sugar and water solution, the length of life of both sexes was very short.

The average length of life of 204 female wasps was 2·31 days, the maximum being 7 days and the minimum 1 day.

The average length of life of 42 male wasps was 2·36 days, the maximum being 5 days and the minimum 1 day.

When carrying out oviposition experiments numbers of newly emerged adult females were enclosed in cellophane sleeves with trees of *A. sophorae* growing in pots. By the end of the third day very few wasps were still alive and these very enfeebled, and by the end of the fourth day all were dead, the length of life of ovipositing females being particularly short.

Parthenogenesis.

On 28th November, 1936, females of *T. acaciae-longifoliae* were allowed to oviposit in *Acacia sophorae* and in November and December, 1937, 75 adults emerged from the galls on this tree; all were females. These were again allowed to oviposit in this tree and in spring 1938 a further 108 adults of *T. acaciae-longifoliae* emerged and again all were females. Thus the only progeny of unfertilised individuals obtained were all females. Only females emerged from galls on a number of the trees under observation. As wasps tend to reinfest the same tree year after year, it would appear that in such cases oviposition has continued for some years without fertilisation.

Percentage of sexes.

The numbers of males and females of *T. acaciae-longifoliae* emerging from galls collected from various suburbs of Sydney in 1936 are set out in table II.

TABLE II.

Number of females and males of *T. acaciae-longifoliae* emerging from galls on various species of acacia in the Sydney district in 1936.

Species of Acacia	No. of trees from which galls were collected	No. emerging	No. emerging ♀	No. emerging ♂	% of wasps emerging	
					♀	♂
A. longifolia .	4	190	188	2	98·95	1·05
A. floribunda .	3	597	308	289	51·59	48·41
A. sophorae .	1	127	120	7	94·49	5·51
Total .	8	914	616	298	67·39	32·61

It will be seen that there is considerable variation in the numbers of the sexes emerging from the different species of *Acacia*. Of a total of 914 adults which emerged in 1936, 616, or 67·4 per cent., were females and 298, or 32·61 per cent., were males. It will be noted, however, that in the combined emergence from three widely separated trees of *A. floribunda* the number of males almost equalled that of females. On the other hand, from three trees of *A. longifolia* only two males emerged from one tree and from the remaining two trees females only emerged. As pointed out earlier, the progeny of unmated females were all females, and these trees probably carried galls which were formed as a result of oviposition by unmated females only.

Oviposition.

Wasps on cutting their way out of the galls are found to have the abdomen filled with fully developed eggs, but adults emerging from pupae dissected from galls and kept in petri dishes contain, on changing to the adult stage, no eggs ready for deposition, the eggs apparently maturing while the adult is eating its way out of the gall.

Oviposition can occur as soon as the adult emerges. When enclosed with small trees the female wasps run actively up the stems until they reach the younger and softer growth towards the tips. They then utilise the tips of the antennae to locate an oviposition site, and in the case of *A. longifolia*, *A. sophorae* always, and *A. floribunda* usually, the female selects a point at

the junction of the phyllode and the stem. At the time the wasps emerge, viz., November and December, there is a very minute swelling at this point, which represents the developing flower bud covered by the floral bracts (pl. 1, fig. A). Though these floral bracts are in evidence at the time the wasps emerge and the floral spike bursts through a month or so later (pl. 1, fig. A), flowering does not occur for seven or eight months after the adult wasps have emerged and oviposited.

Occasionally females were observed ovipositing at the tips of young branches on *A. floribunda* where there was no external evidence of developing flower buds.

The abdomen is normally depressed, so that its tip rests near the surface of the twig. The ovipositor is brought down independently, so that its tip rests on the surface of the floral bract and it is then thrust into the plant tissues. It can be completely embedded very rapidly, ten seconds and fifteen seconds being two periods recorded for this operation. On completion the ovipositor is withdrawn, and the wasp may move forward a little and immediately oviposit in the same bud, but not uncommonly it rests for a few moments and cleans the antennae and legs.

The time occupied in oviposition varies considerably. The average of ten ovipositions was 4 minutes 53 seconds, the maximum 8 minutes 35 seconds and the minimum 2 minutes 55 seconds.

Occasionally unsuccessful attempts to embed the ovipositor were observed. From one bud 1 mm. in diameter, seven eggs were dissected. In some cases the eggs were touching, and in others they were slightly separated by plant tissue. Another bud approximately half a millimetre in diameter contained six eggs and a third bud from the same twig contained four eggs.

The greatest oviposition occurred during the first 24 hours after emergence. In some cases oviposition was observed on the second and third day, but no wasps were ever observed ovipositing on the fourth day, so that the oviposition period of individual females is extremely brief.

The first adults emerged on 8th November and emergence continued until 25th December, 1936, and as the length of life of adults is so short, it is evident that the main oviposition takes place during November and December.

Ten newly emerged females were dissected and found to contain the following number of eggs: 447, 501, 467, 353, 421, 396, 335, 458, 307, and 413, the average number being 409·8 eggs per female.

Larval development.

As pointed out when discussing the morphology, five larval stages occur. At no stage do the larvae possess any power of locomotion, but in the later stages, and particularly the last, the larva can inflex the body rapidly and move its position slightly and if these actions be repeated a number of times the larva can move some little distance.

As in the case of the larva of *Tepperella trilineata* (Noble, 1938A), in the early larval stages the head is relatively inconspicuous, but with subsequent moults, the head becomes more conspicuous, the larvae become more tapering and though yellowish-green in the earlier stages, with the development of fat-body the mature larva appears quite white. The progressive development of the respiratory system has been described. By the time it reaches the fourth stage the plant tissues no longer fit closely round the larva, and it is then provided with a complete open respiratory system.

First stage larvae were present in dissections carried out in the first week in January, 1937. In a large number of dissections carried out on 2nd February,

1937, only second stage larvae were observed, but on 15th February, 1937, second, third and fourth stage larvae were present. In dissections on intervening dates up to 6th June, 1937, all stages up to the fourth were present, but on that date first, second, third and fourth stage larvae were present in the minute galls on the same tree.

TABLE III.

Results of dissection of galls from one tree of *A. floribunda* in 1936 and 1937 showing the stages of *T. acaciae-longifoliae* present.

Date of dissection	No. of cells examined	Larvae						Pupae	Adults
		Stage I	Stage II	Stage III	Stage IV	Stage V			
						immature	mature		
1936. Galls									
16. x.36	21	—	—	—	—	15	5	1	—
22. x.36	103	—	—	—	—	51	41	11	—
28. x.36	112	—	—	—	—	27	44	41	—
1.xi.36	26	—	—	—	—	3	15	8	—
15.xi.36	32	—	—	—	—	12	16	4	—
24.xi.36	50	—	—	—	—	—	21	27	2
Total .	344	—	—	—	—	108	142	92	2
1937. Galls									
8. vi.37	18	1	6	6	5	—	—	—	—
8. vii.37	26	—	2	4	19	1	—	—	—
20. vii.37	13	—	—	—	5	8	—	—	—
16.viii.37	49	—	—	—	—	49	—	—	—
10. ix.37	21	—	—	—	—	20	1	—	—
1. x.37	57	—	—	—	—	55	2	—	—
12. x.37	30	—	—	—	—	26	4	—	—
26. x.37	65	—	—	—	—	31	25	9	—
10. xi.37	68	—	—	—	—	6	33	29	—
Total .	347	1	8	10	29	196	65	38	—

1936 { First adult of *T. acaciae-longifoliae* from these galls emerged 25. xi.36.
1936 { Last " " " " " 25.xii.36.
1937 First " " " " " 25. xi.37.

In table III is set out the results of the dissection of galls from one tree of *A. floribunda* in the spring of 1936 and from the same tree in the last half of 1937. It will be seen that the first fifth stage larva was dissected on 8th July, 1937, and that the first mature larva was not dissected until 10th September, 1937, and that there were still a few immature last stage larvae present on 10th November, 1937, though pupae were present on 26th October. It is evident that there is considerable overlapping in the various larval stages but that, speaking generally, there is progressive larval growth during the late summer, autumn, winter and early spring.

It is of interest to note that at an early stage, segregation of the sexes takes

place in the gall cells, so that the female larva is found in a large central spherical cell, while male larvae are found in much smaller elongate cells in the periphery of the gall. Such segregation is much more obvious when the galls reach maturity, but it was quite evident in galls dissected from *A. floribunda* on 8th June, 1937, although the galls were still only approximately one-twelfth of an inch in diameter and had only recently become evident.

As pointed out earlier, male adults are smaller and much less robust than females, and a corresponding difference in size is also evident in the larvae. At the time the galls reach maturity the spherical cell containing the female larva is several times the volume of the latter, while the cells in which the male larvae are found are cylindrical with rounded ends and there is only a very limited space between the plant tissues and the integument of the larva.

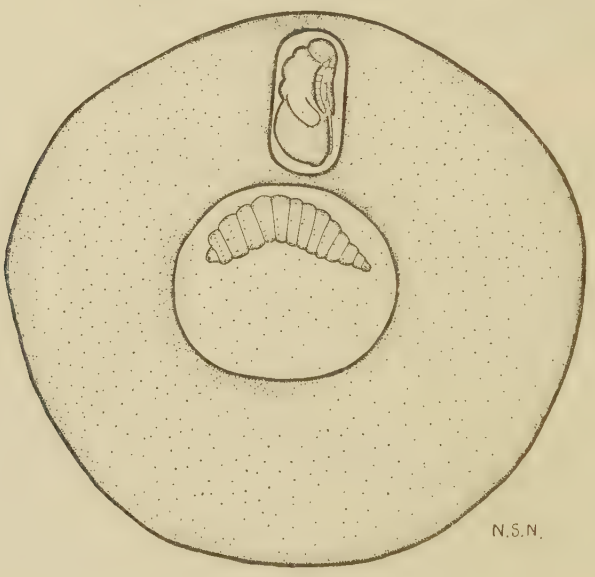

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Fig. 5.—Cross-section of a mature gall on *Acacia floribunda* showing a mature female larva of *T. acaciae-longifoliae* in the central spherical cell, with a male pupa of the same species in a narrow elongate cell in the periphery (× 18).

These male cells are usually at right angles to the surface, and sometimes they are found grouped round the stem of the gall. In fig. 5 is shown a section through a gall in which a mature female larva is in the central spherical chamber and a male pupa is in the peripheral cell.

Froggatt (1907) quotes Mayr (1905) as having noticed this segregation of the sexes in the galls on *A. pendula* caused by *Trichilogaster pendulae* Mayr.

Froggatt (1923), discussing *Trichilogaster*, stated that usually a male and a female egg is deposited and later a male and a female wasp emerge. In some galls caused by *T. acaciae-longifoliae* as many as five female pupae were found in one gall in the absence of males, and three males have been found in a single gall. It is, however, of interest to note that males were never found in galls in the absence of females.

The pupal stage.

The pupae of *T. acaciae-longifoliae* are at first white, but in a few days change to shining black. The average length of the female pupa is 3·66 mm., the maximum being 3·80 mm., and the minimum being 3·49 mm. The last larval skin can frequently be seen adhering to the tip of the abdomen of the pupa.

Unlike the female pupae, male pupae do not change colour rapidly during the pupal period. The colour for the greater part of the time is creamy white. The antennae, tips of the wing buds and the legs then change to light brown and a few days before emergence the pupa becomes dark brown.

In table III it may be seen that the first pupa was found in galls on *A. floribunda* on 16th October, 1936, and the first adult was found in a gall on the same tree on 24th November, the day before the first adult emerged normally

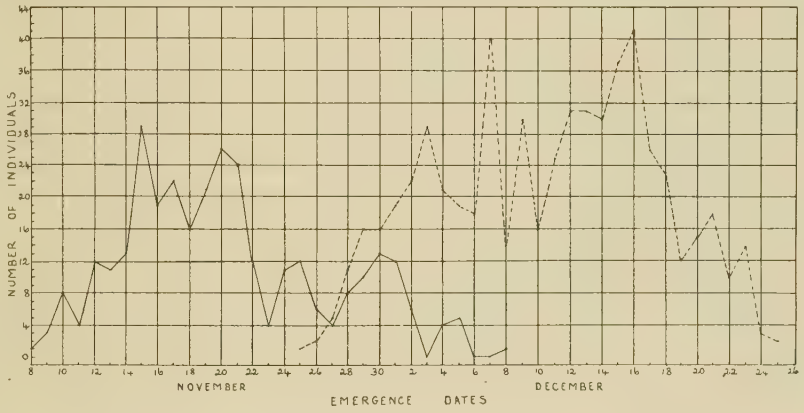

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Fig. 6.—Graph showing daily emergence of adults of *T. acaciae-longifoliae* from acacia galls in the Sydney district in 1936.
——— 317 adults from galls on *Acacia longifolia*.
- - - - - 597 adults from galls on *Acacia floribunda*.

from the galls. It is evident that the pupal period is approximately five weeks, but the exact period was not ascertained.

Emergence of adults.

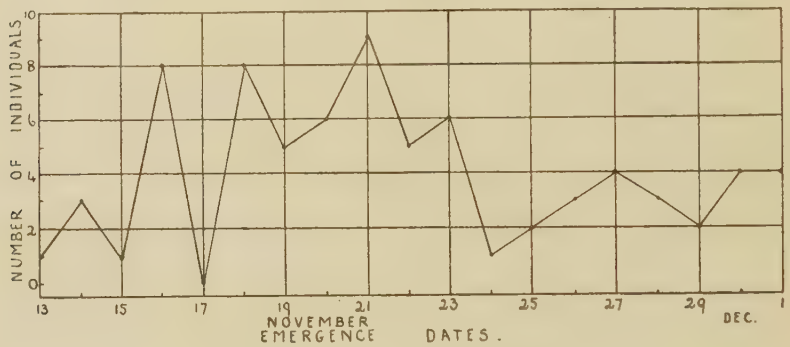
Adults emerged from the galls by eating out a cylindrical channel to the exterior, leaving a circular hole in the gall surface. As will be shown later in discussing the galls in more detail, the female is obliged to eat through a considerable quantity of plant tissue to reach the exterior, but the male is always in a cell very near the surface of the gall.

Large numbers of mature galls were collected just prior to the emergence of any adults and were retained in jars until all the adults had emerged. In fig. 6 is shown graphically the daily emergence of 317 adults of *T. acaciae-longifoliae* from galls on *A. longifolia* growing in various parts of the Sydney district in the spring and early summer of 1936. It will be seen that the first emergence occurred on 8th November, 1936, and that emergence continued daily until 8th December, *i.e.*, an emergence period of 31 days. The first

adult emerged from pupae in petri dishes, taken from galls on *A. longifolia* on 4th November, *i.e.* only four days before the first adults ate their way out of the galls normally.

In fig. 6 is also set out graphically the daily emergence of 597 adults of *T. acaciae-longifoliae* in 1936 from galls from *A. floribunda*. The first emergence occurred on 25th November and emergence continued daily until 25th December *i.e.*, an emergence period of 31 days, as in *A. longifolia*. However, emergence from the galls on *A. longifolia* commenced 17 days earlier, though in some cases the two species of *Acacia* were growing side by side.

It is of interest to note that in dissection of galls on a tree of *A. floribunda* growing at Killara, Sydney, on 7th January, 1937, several normal adults and one prepupa of *T. acaciae-longifoliae* were found, so that if these individuals had been undisturbed and succeeded in emerging later the dates of emergence would have been considerably later than those of the majority of this species.



7

Fig. 7.—Graph showing emergence of 75 adults of *T. acaciae-longifoliae* from galls experimentally produced on *Acacia sophorae*. Eggs laid 28.xi.1936.

Time spent in the various stages of the life-cycle.

The life-cycle is annual. Oviposition occurs mainly during November and December and first stage larvae were present in the first week in January 1937. As the pupal period is approximately five weeks, it is evident that the larval period occupies the greater period of the life-cycle and lasts from nine to ten months.

In fig. 7 is set out the daily emergence of 75 adults of *T. acaciae-longifoliae* from galls on *A. sophorae* in the spring and early summer of 1937. Wasps were allowed to oviposit in flower buds on this tree on 28th November, 1936, only. It will be seen that the earlier emergents had a life-cycle slightly less than one year, the last wasps to emerge exceeded the one-year life-cycle by three days only. These adults were allowed to oviposit in this tree again and the first adult of the succeeding generation emerged on 14th November, 1938.

Observations on the Development of the Galls.

It has already been pointed out that in all but a limited number of cases on *A. floribunda*, the great majority of ovipositions on all three species of

Acacia occur in the young developing flower buds, which at the time of oviposition are covered by the floral bracts, the buds being then just visible in the axils of the phyllodes (pl. 1, fig. A). Occasionally on *A. floribunda* the eggs are laid in the tips of the young stems, where flower buds are not at the time visible. The time of appearance of these flower buds on the various species of *Acacia* may vary by several months.

It has been pointed out that oviposition occurs mainly during November and December. At the time the later adults emerge the majority of the flower buds have burst through the floral bracts and appear as minute green cone-like structures (pl. 1, fig. A). The females of *T. acaciae-longifoliae* will not attempt oviposition in these flower buds, after the latter have burst through the floral bracts, though it may still be six or seven months before these buds flower.

Later these floral buds begin to elongate, and some months before flowering project from the base of the phyllodes as elongate spikes up to an inch and a half long. Along them extends a series of minute buds each of which will give rise to a single acacia flower, the inflorescence being in the form of a spike. These floral spikes are much more elongate and slender on *A. floribunda* than on either *A. sophorae* or *A. longifolia*. A number of floral spikes usually project from the axil of each phyllode, on *A. longifolia* up to five being quite common, while on *A. sophorae* all numbers up to seven have been observed.

In floral buds in which oviposition has occurred the spike usually breaks through the floral bracts, but the normal extension to an elongate spike may never take place, so that ultimately a globular gall develops in the axil of the phyllode (pl. 1, fig. B). Such galls usually have some flower buds scattered over their surfaces. In other instances, though oviposition has occurred, the extension of the floral spike takes place in a normal manner and there is no indication that egg-laying has taken place until several weeks prior to flowering, when extremely minute swellings appear somewhere along the floral spike. The early development of such galls on *A. floribunda* is shown in pl. 1, fig. C. It may be seen that most of these galls are found on the end of the floral spike but that in other instances the gall has formed at the base of the spike, and the latter has extended out more or less normally beyond the gall. It is quite common to see a globular gall form in one axil and for several normal spikes to project from this same axil.

The position in which the galls develop varies in different trees of the same species of *Acacia*. Thus trees of *A. floribunda* were under observation in 1936 and 1937 in which the great majority of galls formed in the axils of the phyllodes, and the floral spikes never became visible. On several other trees of *A. floribunda* in 1936 and 1937 the great majority of the galls formed at the ends of the long slender floral spikes. On trees of *A. longifolia* growing in my home and which were used for experimental gall development, most of the galls formed in the axils of the phyllodes, but a limited number formed at the tips of the floral spikes. On *A. sophorae*, also growing at my home, the floral spikes which are rather thick and fleshy extended out normally following an oviposition and galls developed subsequently at various points along these spikes, few being terminal.

Where eggs have been laid in the terminal buds on *A. floribunda*, the first external evidence that oviposition has occurred appears in an unusual twisted and downward growth of the terminal phyllodes, coupled with a very slight thickening of the terminal shoot. This has been observed as early as February, slightly less than three months after oviposition. In the great majority of

cases, however, there is no external evidence whatever of gall development until three or four weeks prior to flowering. As the various species of *Acacia* concerned flower in July, August and September, it is clear that external evidence of the insects' activity is generally not present until seven months after oviposition. Thus though the life-cycle is annual, galls are only present on the trees for approximately five months of the year. This is in direct contrast to several other gall wasps (Noble, 1936, 1938A) in which external evidence of abnormality of the plant tissues occurs soon after the larvae have hatched, and it is not long after this that definite galls are present.

When the minute galls caused by *T. acaciae-longifoliae* first become evident in the early winter they are usually more or less spherical and dissection shows that the larvae within them may already have reached the third or fourth stage.

Trees remain in flower for approximately two months, and during this time very rapid growth of the galls takes place, all being more than half-size at the completion of flowering, and in some instances the galls may have almost reached their maximum size at this time. The flower buds on the floral spikes bearing galls open in a normal manner and even flower buds on the gall surfaces may open, but here there is more evidence of abnormality. Some of these flower buds never completely open and others open after the remainder of the tree has finished flowering.

As the galls formed in the axils of the phyllodes increase in size they become closely attached to the stem of the tree, but where galls have developed on the ends of the floral spikes these spikes persist after flowering and form a stem attaching the gall to the tree.

During the first three larval stages the plant tissues fit closely against the integument of the young larvae, but by the time they reach the fourth stage there is a space between the integument of the larva and the inner wall of the gall chamber. By the time the larva reaches the fifth stage it is found usually in a spherical central cell or chamber surrounded by an extensive mass of green plant tissue. The galls reach their full size in the spring, at the time the larvae reach maturity, and only a few weeks after flowering is complete. Daily observations on a tree of *A. sophorae* growing at my home were made from the time of oviposition until the development of the galls and the emergence of adults in the following year. Female wasps of *T. acaciae-longifoliae* were allowed to oviposit in this tree for one day on 28th November, 1936. At that time all of the floral spikes were enclosed in the floral bracts. During the following three weeks the floral spikes burst through their enclosing bracts, and the young inflorescence became visible. These gradually extended and the flower buds were visible on the tree for approximately six months before flowering. Very slight thickening of some spikes was observed on 8th June, 1937. The first flower opened on 18th July, there being then very small, but definite galls present. The last floral spike bloomed on 11th September, the tree thus being in flower for a period of 55 days, and during this flowering period there was a very great increase in the size of the galls, particularly during the last few weeks of the flowering period. A few of the galls were almost full size at the time the tree finished flowering, but the majority were not quite full grown, though by 3rd October all of the galls had reached their full size and several cells on examination at that time were found to contain mature larvae. The daily emergence of adults from the galls on this tree is set out in fig. 7. It will be seen that the first adult emerged on 13th November, 1937.

Similar observations were made on this tree in the following season with

very similar results. The first flower appeared on 25th July, 1938, seven days later than the previous year, and the galls were almost mature on the completion of flowering on 5th September, 1938, and the first adult wasp emerged from these galls on 14th November, 1938, only one day later than the first emergence from the same tree in the preceding year.

It is of interest to note that on this tree early in March, 1937, two definite galls were evident and by the end of May were almost full size, though at this time there was no evidence of any of the galls which subsequently became evident on this tree. Oviposition in all instances occurred on the same date, and adult wasps did not subsequently emerge earlier from these early developing galls. In 1938 there was no such abnormal early development of any of the galls on this tree.

Though unilocular galls do occur, plurilocular galls are more common. Of 273 galls examined, the number of cells in each ranged from one to thirteen, the average being 2·45. At maturity some of the plurilocular galls are large and heavy and being attached by very narrow stems may in windy weather be broken off and fall to the ground before any of the occupants have emerged.

As stated earlier, various species of wasps destroyed the host and subsequently emerged from the galls. Where the host larva was permitted to reach maturity prior to destruction the galls reached their full size. If, however, the host larva was killed at an early stage, as happened in some instances, the galls ceased to develop further. Such small galls become quite hard and woody and in the spring it was usual to see a percentage of these small galls on all the trees under observation, offering a marked contrast to the large green fleshy galls which had then reached their full size.

In plurilocular galls if the normal occupant of one cell only is destroyed at an early stage that portion of the gall fails to develop further, so that a small hard rounded area develops on an otherwise green fleshy gall.

When the galls first become evident those on some trees are covered with an extensive grey pubescence, but as they increase in size they lose their grey appearance and become bright green. A maroon coloration on part or occasionally on almost all of the gall surface may be present when the galls are quite small and on most galls a part of the surface is maroon at maturity, but sometimes galls have been observed to remain entirely green throughout development. The mature galls have been described in the introduction and photos are shown on pl. 2, figs. A, B, and C.

Though the plurilocular galls are of various shapes, the majority of galls are rounded and smooth, each protuberance usually indicating the presence of a female cell.

Unilocular galls on the various species of *Acacia*, with few exceptions, at maturity are perfect spheres, and on cutting these open the gall chamber, which is spherical and which contains the mature larva or pupa, is in a central position. Ten typical unilocular galls from various acacias were cut in halves and the diameter of the galls and the inner cell were measured, the results being set out in table IV. All that galls contained was pupae of *T. acaciae-longifoliae*. It will be seen that the layer of plant tissue surrounding the inner cell is approximately the width of the latter. The galls on *A. floribunda*, both in total size and in the size of the central gall cell or chamber, are somewhat smaller than in unilocular galls on *A. longifolia*. Sufficient unilocular galls could not be obtained from *A. sophorae*, but the diameter of ten cells in plurilocular galls on this species of *Acacia* were measured and the average was 4·78 mm., the maximum being 5·5 mm., and the minimum 4·0 mm.

Table IV.

Dimensions (in mm.) of Mature Unilocular Galls caused by *T. acaciae-longifoliae* on various species of *Acacia*.

Species of *Acacia*	Diameter of Gall			Diameter of Central Gall Chamber		
	Aver.	Max.	Min.	Aver.	Max.	Min.
A. floribunda . .	12·1	13	10	4	4	4
A. longifolia . .	16·4	17	15	4·6	5	4·5

Both in size and shape the cells or chambers in plurilocular galls are somewhat variable. It should be remembered that these spherical central cells contain only females, and that the males are found in smaller elongate cells in the periphery.

The unparasitised galls are soft green and fleshy throughout their entire growth, never becoming hard and woody, there being no definite protective woody layer, even at the time the insects reach the adult stage. Soon after the first adults emerge the galls commence to shrivel and become hard, black and woody, and during the following months they fall from the trees.

Insects Associated with *T. acaciae-longifoliae* in the Galls.

A number of other species of insects emerged from the galls under discussion. It is of interest to note, however, that there was very great variation in the numbers of the various species of insects occurring in the galls on different acacias, even though they were of the same species and growing comparatively near one another. On some trees it was found that adults of *T. acaciae-longifoliae* far outnumbered all the other insects together, while less commonly on other trees, a very high percentage of the galls yielded parasites instead of host adults.

Adult insects bred from these galls included a moth, the ant-like weevil, *Myrmacicelus formicarius* Chev., an Ichneumon, *Poecilocryptus nigromaculatus* Cam., one Braconid, and nine Chalcidoids, in addition to the primary gall former.

The larva of the moth was found mining in the galls but was not very common. Moreover, on account of the extensive mass of plant tissues surrounding each gall cell, these moth larvae only occasionally penetrated the latter, but when they did so they destroyed the normal occupants. The Braconid and the Ichneumon *Poecilocryptus nigromaculatus* were undoubtedly parasitic on these lepidopterous larvae.

On 10th November, 1938, an apparently normal and mature gall from *A. floribunda* when cut open was found to contain 6 cells, but much of the interior of the tissues had been eaten, evidently by a lepidopterous larva, and the sole occupant of the gall was found to be an adult of *P. nigromaculatus*.

Both *P. nigromaculatus* and the ant-like weevil *Myrmacicelus formicarius* were also bred from galls on *A. decurrens* caused by *Tepperella trilineata* (Noble, 1938A). The larvae of *M. formicarius* feed on the gall tissues, and adults were bred from galls on *A. floribunda* and *A. longifolia*.

The nine species of Chalcidoids included *Coelocyba nigrocincta* Ashmead, two species of *Megastigmus*, one *Megastigmus* (*Epimegastigmus* sp. B.) being considered by Girault to be new, four species of the genus *Eurytoma*, two of which

(*Eurytoma gahani* Noble, 1939 and *Eurytoma* sp. B.) were undescribed, and a species of Callimomid which Girault considered to belong to a new genus and a new species.

Eurytoma gahani also occurred in association with *Tepperella trilineata* in galls on *A. decurrens* (Noble, 1938A). Its life-history in that association was studied in detail by me and will form the subject of a separate paper to be published shortly.

Eurytoma gahani and *Eurytoma* sp. B. occurred much more commonly than any of the other species of Chalcidoids. The eggs of *E. gahani* were deposited alongside the eggs or the young larvae of *T. acaciae-longifoliae.* The two species of larvae live together in the gall cell phytophagously until both reach the fifth stage. At this time the larva of *E. gahani* becomes predatory and devours the larva of *T. acaciae-longifoliae.* As late as 13th February, 1937, larvae of *T. acaciae-longifoliae* on dissection were found to have normal eggs of *E. gahani* adhering to the integument.

Eurytoma sp. B also lays its egg alongside the egg or larva of *T. acaciae-longifoliae,* but the larva of *Eurytoma* sp. B on hatching is very active, and immediately destroys the other cell occupant, completing development phytophagously. As late as 21st June, 1938, normal eggs of *Eurytoma* sp. B were found in cells with normal fourth stage larvae of *T. acaciae-longifoliae.* Observations indicate that the emergence of adults of *Eurytoma* sp. B from the galls was very irregular and somewhat protracted.

A third species of *Eurytoma* was found in gall cells on *A. longifolia* and *A. floribunda* with the pupal remains of the host, indicating that though accompanying the host it did not make any direct attack on the latter until it had reached maturity and pupated.

In the gall cells on some trees there was evidence of an intense struggle for existence, both amongst the same and different species. This competition occurs specially among the various species of *Eurytoma* and all of these as well as the two species of *Megastigmus* individually always destroy the host. Though only one adult can emerge from any gall cell, dissection frequently revealed the remains of various stages of a number of species of Chalcidoids in one cell.

On 13th February, 1937, in one cell one larva and the remains of thirteen eggs of *E. gahani* were found with a third stage larva of *T. acaciae-longifoliae.* In another cell the remains of a fourth stage larva of *T. acaciae-longifoliae* were found with the remains of four eggs of *E. gahani* and nine eggs of *Eurytoma* sp. B, a larva of the latter species being the only living occupant of the cell.

The eggs of three of the species of *Eurytoma* occurring in the galls present certain distinct differences and in one cell of a gall on *A. sophorae* these three types of egg were found, together with the remains of a host larva, the sole living occupant being one third stage *Eurytoma* larva. All the *Eurytoma* eggs consisted of an oval body bearing a short and a very long pedicel, but while that of *E. gahani* was pearly white and smooth, that of *Eurytoma* sp. B was black and smooth. The egg of a third species of *Eurytoma* was also black but the surface of the body of the egg bore a large number of short black sharp pointed spines. This egg was somewhat similar to that of *Eurytoma rosae* (Parker, 1924).

Where the host larva was permitted to reach maturity prior to its destruction, as in the case of *E. gahani,* the galls developed to their full size. Where the host larva is destroyed at an early stage as it is when associated with *Eurytoma* sp. B the galls do not develop further.

Megastigmus (*Epimegastigmus*) sp. B.

This is easily the largest of any of the species of *Megastigmus* observed by me. The length of the body averages 4·65 mm., the maximum being 5·0 mm., and the minimum 4·32 mm. The ovipositor projects on an average 4·65 mm., beyond the end of the abdomen, the maximum being 4·90 mm., and the minimum 4·22 mm. It will be seen that the ovipositor is approximately as long as the wasp itself.

The egg.

The ovarian egg (fig. 8, C) consists of a large elongate oval white body, a short pointed anterior pedicel and an elongate posterior pedicel. The total length of the egg averaged 1·33 mm. The body of the egg was 0·517 mm. in length and 0·139 mm. in width, the long pedicel being 0·768 mm. and the short pedicel 0·048 mm. in length.

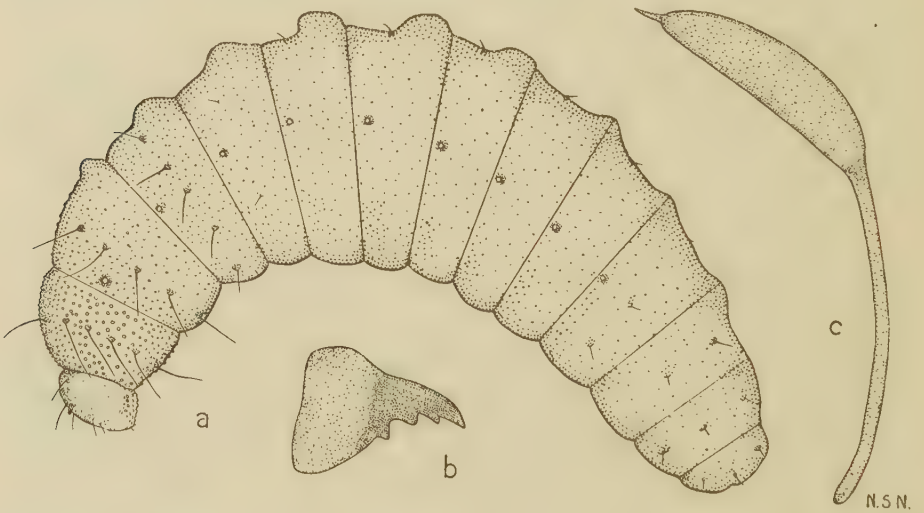


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Fig. 8.—*Megastigmus* sp. B. A, lateral view of mature larva (× 40); B, mandible of mature larva (× 345); C, ovarian egg (× 120).

The mature larva.

The mature larva (fig. 8, A) is white in colour, cylindrical, conspicuously arched and tapering to both ends. It consists of a head and thirteen segments. The length averages 5·64 mm., the maximum being 6·46 mm. and the minimum 5·11 mm. The width averages 1·45 mm., the maximum being 1·51 mm. and the minimum 1·35 mm.

On the ventral surface of the head, all over the first segment, and in limited numbers on the second and succeeding segments there are rounded papillae, which become very minute on the posterior segments. On the first three segments in a median circlet there are numbers of very elongate setae. Setae are present on the remaining segments, but they are much smaller and very limited in number, being somewhat larger and more numerous on the last four segments.

The head is hemispherical in outline and the mouth is ventral. The mandibles (fig. 8, B) are more or less triangular in outline and possess four teeth. The base is amber and the teeth are dark brown. The length averages 0·149 mm., the maximum being 0·152

mm. and the minimum 0·142 mm. Dorsally there is a pair of short truncate cone-shaped amber antennae. Above the antennae to the sides of the head there is a pair of elongate setae, a further pair being between the antennae. To one side of the mandibles there are two pairs of elongate setae, and below the mandibles four pairs of rounded sensillae and two pairs of minute sensory setae can be distinguished. Nine pairs of spiracles are present, one pair being present on each segment from two to ten inclusive, there being a well-developed tracheal system.

Biological notes.

The detailed biology of this species has not been studied. Numbers of females were enclosed with small trees of *Acacia sophorae* in which *T. acaciae-longifoliae* had oviposited a few days previously, but they did not display any interest or attempt to oviposit.

The first adult of *Megastigmus* sp. B emerged on 14th November, 1936, and adults continued to emerge in limited numbers until 25th January, 1937, *i.e.*, emergence commenced soon after the first host adults emerged but continued a month later.

Oviposition was never observed, but the ovarian egg of *Megastigmus* sp. B is considerably larger than the egg of *T. acaciae-longifoliae* so that its oviposition habits must be entirely different to those of *Epimegastigmus brevivalvus*, which deposits its egg within that of its host (Noble, 1938).

No internal parasitic larvae were ever found in the larvae of *T. acaciae-longifoliae.*

During November and December, 1936, and again in 1937 and 1938, numbers of gall cells on the various acacias were found to contain the remains of dead pupae of *T. acaciae-longifoliae* together with either the mature larvae or pupae of *Megastigmus* sp. B. In some instances these host pupae, though dead, were still fairly normal in shape even though pupae of *Megastigmus* sp. B were present. In others the pupae of *T. acaciae-longifoliae* had been completely devoured, leaving only the black pulverised minute fragments of the host pupal integument, adhering to the larva or pupa of *Megastigmus* sp. B.

Early in November, 1936, a third stage larva of *Megastigmus* sp. B was found in a cell with a normal pupa of *T. acaciae-longifoliae.* From the foregoing observations it is evident that *Megastigmus* sp. B is not an internal parasite of *T. acaciae-longifoliae.* Moreover as the larva of the latter species is allowed to reach the pupal stage it is evident that until this time *Megastigmus* sp. B must live phytophagously in the galls.

As most American and European members of the genus *Megastigmus* are phytophagous it would appear that *Megastigmus* sp. B represents an intermediate stage between types such as *Epimegastigmus brevivalvus* (Noble, 1938), which is parasitic and European and American phytophagous forms.

On a number of occasions perfectly normal-sized unilocular galls on *A. floribunda* were found to contain only the pupa of *Megastigmus* sp. B, thus showing that the presence of this species in no way prevented normal gall formation.

Insects Utilising Galls after Adults of *T. acaciae-longifoliae* have Emerged.

As has already been pointed out, the adult wasp on eating its way out of the gall, leaves behind a spherical chamber, which is from four to five millimetres in diameter. Moreover, at this time the inner surface of this chamber, unlike that of other galls studied, is not dry and hard, the inner cells containing quantities of cell-sap. It has been found that three species of insects

utilise these vacated gall chambers, for temporary homes, while the galls are still green and hanging on the trees. These insects are a species of ant, a mealybug and a thrips.

The ants were found in vacated galls on *A. floribunda* growing at Killara, Sydney. The first were found on 17th December, 1936, and occasional colonies were found until 16th February, 1937. The colonies were limited in number, the largest consisting of three adults, two pupae, five larvae and one egg. The ant, which is brown in colour, was forwarded to Mr. T. Clark of the National Museum, Melbourne, who informed me that it belonged to the genus *Monomorium*, the species probably being *M. froggatti* Forel.

During January and February, 1937, on *A. floribunda* growing at Killara and also at the Botanic Gardens, Sydney, colonies of a species of mealybug were often found in the gall chambers recently vacated by adults of *T. acaciae-longifoliae*. During December, 1936, and January, 1937, and as late as 12th February, 1937, colonies of a species of thrips were also found in the vacated galls on *A. floribunda* growing in the Botanic Gardens, Sydney. A number of eggs, larval and pupal forms and adults were found in single chambers and like the mealybugs they were feeding on the inner surfaces of the gall chambers. As the galls shrivel and become hard and woody a few months after the normal occupants leave them, it is evident that these insects must find some other breeding location during the greater part of the year.

Summary.

The detailed life-history of *Trichilogaster acaciae-longifoliae* (Froggatt), a Perilampid wasp causing galling of the flower-buds of *Acacia floribunda*, *A. longifolia* and *A. sophorae*, is described.

The life-cycle is annual, the larval period being nine to ten months and the pupal period approximately five weeks.

Adult wasps which emerge mainly during November and December are ready to oviposit on the day of emergence.

The average length of life of female wasps in the laboratory was 2·31 days, the maximum being 7 days and the minimum 1 day. The average length of life of male wasps was 2·36 days, the maximum being 5 days and the minimum 1 day.

Of 914 adults which emerged in 1936, 616 or 67·4 per cent. were females and 298 or 32·6 per cent. were males, but females only emerged from galls on some trees.

The average number of eggs within ten females was 409·8, the maximum being 501 and the minimum 307. The egg, which prior to deposition consists of two white oval bodies connected by a narrow tube, is inserted in the minute flower-buds when the latter are still covered by the floral bracts in the axils of the phyllodes. After deposition the protoplasmic contents pass into one body of the egg, leaving a long flaccid pedicel. Five larval stages occur and are described.

Though the minute flower-buds are present at the time of oviposition in November and December the trees do not flower until the following July, August and September, and minute galls are usually first in evidence about three weeks before flowering commences. There is very great growth of the galls during the period that the tree is in flower, the galls reaching maturity at the time the larvae in them mature in the early spring.

Less commonly the presence of the insects may be indicated by a slight

thickening of the terminal shoots and a downward twisting of the terminal phyllodes, observable a few months after oviposition. The average number of cells in each of 273 galls was 2·45, the maximum being 13 and the minimum 1.

The galls at maturity are large soft green and fleshy, and rounded, frequently with a maroon coloration on part of the surface. Unilocular galls are almost perfect spheres.

Female larvae and pupae are to be found in large spherical central cells, but males occur in narrow elongate cells in the periphery of the galls.

Mining lepidopterous larvae occurred in limited numbers in the galls, but killed few of the normal occupants. An Ichneumon, *Poecilocryptus nigromaculatus* and a species of Braconid, which emerged in limited numbers were probably parasitic on these lepidopterous larvae.

Several adults of the ant-like weevil *Myrmacicelus formicarius* also emerged from the galls.

In addition to *T. acaciae-longifoliae* nine other species of Chalcidoids were bred from the galls, five species being apparently undescribed.

Notes on the life-histories of several new species of *Eurytoma* and one new species of *Megastigmus*, the larvae of all of which were both predatory and phytophagous, are included.

After the emergence of adults of *T. acaciae-longifoliae* the vacated gall cells are sometimes occupied by a species of ant, *Monomorium* sp., a species of mealybug, and a species of thrips.

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References.

Anderson, R. H., 1934, *The trees of New South Wales.* Sydney, N.S.W. 244 pp.

Froggatt, W. W., 1892, Notes on Australian Cynipidae with descriptions of several new species. *Proc. Linn. Soc. N.S.W.* **7** : 152–156.

——, 1907, *Australian Insects.* Sydney, N.S.W. : 80.

——, 1923, *Forest insects of Australia.* Sydney, N.S.W. : 6.

——, 1925, Notes and exhibits. *Proc. Linn. Soc. N.S.W.* **50** : xliv.

Gahan, A. B., 1922, A list of phytophagous *Chalcidoidea* with descriptions of two new species. *Proc. ent. Soc. Wash.* **24** : 35.

Girault, A. A., 1913, Some new Australian genera in the hymenopterous families Eurytomidae, Perilampidae, Eucharidae and Cleonymidae. *Canad. Ent.* **45** : 220–228.

——, 1913a, Australian Hymenoptera Chalcidoidea V. *Mem. Q'land Mus.* **2** : 300, 301, 302.

——, 1915, Australian Hymenoptera Chalcidoidea V. Suppl. *Mem. Q'land Mus.* **3** : 303.

——, 1916, Australian Hymenoptera Chalcidoidea Gen. Suppl. *Mem. Q'land Mus.* **5** : 222.

Mayr, G., 1905, Hymenopterologische Miszellen iv. *Verh. zool. bot. Ges. Wien.* **55** : 529–575.

Noble, N. S., 1936, The citrus gall wasp, *Eurytoma fellis* Girault. *N.S.W. Dept. Agr. Sci. Bull.* **53** : 41 pp.

——, 1938, *Epimegastigmus* (*Megastigmus*) *brevivalvus* Girault, a parasite of the citrus gall wasp, *Eurytoma fellis* Girault, with notes on several other species of hymenopterous gall inhabitants. *N.S.W. Dept. Agr. Sci. Bull.* **65** : 46 pp.

——, 1938A, *Tepperella trilineata* Cam., a wasp causing galling of the flower-buds of *Acacia decurrens*. *Proc. Linn. Soc. N.S.W.* **63** : 389–411.

——, 1939, A new species of Chalcid associated with *Tepperella trilineata* Cam. *Proc. Linn. Soc. N.S.W.* **64** : 223–241, 12 figs.

Parker, H. L., 1924, Recherches sur les formes post-embryonnaires des Chalcidiens. *Ann. Soc. ent. France* **93** : 261–379.

Plate 1A. Right : Twig from *Acacia longifolia* showing the young flower-buds in the axils of the phyllodes at the stage at which oviposition occurs. The floral spikes are still enclosed in the floral bracts.

Left : Twig from *A. longifolia* showing the short cone-like young floral spikes, which have burst through the floral bracts. These flower-buds are too advanced for oviposition. The phyllodes in both instances have been trimmed. Photographed 22.xii.1937. (Slightly less than natural size.)

Plate 1B. Young galls on *Acacia floribunda* a few weeks after they have commenced to develop. In this instance oviposition and subsequent larval activity have prevented the development of the floral spikes in contrast to Plate 1C. The phyllodes have been trimmed. Photographed 22.vii.1937.

Plate 1C. Young galls on *Acacia floribunda* shortly after they have commenced to develop. In this instance, although oviposition occurred in the minute flower-buds, the floral spikes have continued to develop, and advanced flower-buds have just commenced to open. Photographed 22.vii.1937.

Plate 2A. Fully developed galls on *Acacia floribunda* caused by *Trichilogaster acaciae-longifoliae*. Photographed 28.x.1936.

Plate 2B. Mature galls on *Acacia longifolia*, caused by *T. acaciae-longifoliae*. Photographed 15.x.1936.

Plate 2C. Fully developed galls on *Acacia sophorae* produced experimentally by enclosing females of *Trichilogaster acaciae-longifoliae* with small trees growing in pots. Eggs laid 28.xi.1936. First adult emerged on 13.xi.1937. The phyllodes, which are long and strap-like, have been trimmed off. Photographed 9.xi.1937

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N. S. Noble. **Trichilogaster acaciæ-longifoliæ.**

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